Notes on *Virginia* (Reptilia: Colubridae) in Virginia

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ABSTRACT.— Female *Virginia striatula* in central Virginia produce an average of 6.0 young/litter and reproduce annually. Litter size, frequency of reproduction, oviductal egg size and size of newborn young are greater than those of *V. striatula* from the southwestern part of its range in Texas. Absence of size classes below those of mature snakes suggests high mortality of subadults or perhaps sampling bias caused by behavioral differences between adults and young. Ventral and subcaudal counts of *V. striatula* from Virginia are low; comparison of these with the few measurements from the rest of the range indicates there is significant geographic variation, although the pattern is not clear. Data from *Virginia v. valeriae* collected in the same area are also provided.

INTRODUCTION

The genus *Virginia* includes two species of small, secretive, ground-dwelling snakes: the Rough Earth Snake, *Virginia striatula* (Linnaeus), and the Smooth Earth Snake, *Virginia valeriae* (Baird and Girard). In Virginia, *V. valeriae* is represented by the nominate subspecies, *V. v. valeriae*, the Eastern Earth Snake. Both species of *Virginia* are found throughout much of the southern tier of states from eastern Texas and Oklahoma to the Atlantic Coast (Conant 1975). The Rough Earth Snake reaches the northern edge of its known distribution along the Atlantic Coast in central Virginia. The Eastern Earth Snake occupies most of Virginia, and its distribution extends northward to New Jersey and Pennsylvania.

Few papers containing quantitative data have been published regarding *V. striatula* (Clark 1964; Clark and Fleet 1976), and nothing has been reported regarding the species in Virginia. As part of a long-term study of reptiles at the northern edge of their range, we report here morphometric and reproductive data for a population of *V. striatula* in central Virginia. The collecting location is near the apparent northern extreme of the species' range (Conant 1975; Martof et al. 1980). Additionally, we provide information about a smaller sample of *V. v. valeriae* collected in the same area.

MATERIALS AND METHODS

Data were taken from freshly collected specimens and preserved material in the Virginia Commonwealth University herpetological collection. Twenty-six male and forty-six female *V. striatula* are included. Four of the females lacked tail tips, so sample sizes of subcaudal counts and tail lengths are reduced accordingly. Thirteen male and seventeen female *V. valeriae* are also included. Most specimens were collected in eastern Henrico County, about 16 km east of Richmond. Two *V. striatula* and three *V. valeriae* were obtained from sites in Chesterfield County, approximately 20 km south of the Henrico locality. Snakes were collected in the period 1974-1980, but 85% of the sample was obtained during 1978-1980. The Henrico site is covered by a secondary growth of loblolly pine, *Pinus taeda*, within which are piles of roofing, discarded furniture, and tires. Besides *Virginia*, 14 other species of reptiles have been collected at the site, including one turtle, *Terrapene carolina*; five lizards, *Sceloporus undulatus hyacinthinus*, *Scincella lateralis*, *Cnemidophorus sexlineatus*, *Eumeces fasciatus* and *Eumeces inexpectatus*; and eight other snakes, *Storeria occipitomaculata*, *Storeria dekayi*, *Carphophis amoenus*, *Diadophis punctatus*, *Heterodon platyrhinos*, *Coluber constrictor*, *Elaphe obsoleta*, and *Agkistrodon contortrix mokasen*. *Virginia striatula* is the most common reptile at this locality.

Snout-vent and tail lengths were measured to the nearest millimeter. Ventral and subcaudal scales were counted in standard fashion (e.g. see Schmidt and Davis 1941) and the style is comparable to that used by Clark and Fleet (1976). Sex, number of ova/embryos, and stomach contents were determined by dissection. Testes and ova lengths were measured to the nearest millimeter. Embryos were removed and examined microscopically to determine extent of development. Developmental stages were assigned according to criteria in Zehr (1962). The 5% level of significance ($P<0.05$) was used in all statistical tests.

RESULTS

Morphometrics

There is no statistical intersexual difference in snout-vent lengths of *V. striatula* ($t = 1.5$, $df = 70$; Table 1), but significant differences exist between tail lengths ($t = 2.6$, $df = 63$), tail length/snout-vent length ratios ($t = 6.9$), ventral scale counts ($t = 2.6$) and subcaudal counts ($t = 9.3$). There also is no statistical difference between snout-vent length of sexes of *V. valeriae* ($t = 0.7$, $df = 28$; Table 2). However, statistical differences do exist between tail lengths ($t = 3.0$, $df = 28$), tail length/snout-vent length ratios ($t = 10.1$), ventral scale counts ($t = 5.7$) and subcaudals ($t = 13.3$).

Table 1. Comparison of *Virginia striatula* from Virginia and Brazos County, Texas. All values are means ± one standard error; sample sizes are in parentheses. All lengths are in mm; SVL = snout-vent length.

Measurement	Present study	Clark (1964)
Litter size	6.0 ± 0.3 (24)	4.9 ± 0.5 (16)[a]
SVL; males	164.2 ± 6.6 (26)	148.0 ± 2.5 (169)
SVL; gravid females	210.1 ± 3.9 (24)	226.0 (16)[b]
SVL; all females	179.7 ± 7.6 (46)	167.2 ± 3.6 (155)
Tail length; males	41.5 ± 1.8 (26)	20.6 ± 0.1 (133)
Tail length; females	35.0 ± 1.5 (42)	16.9 ± 0.1 (126)
Tail length/SVL; males	0.253 ± 0.004 (26)	-
Tail length/SVL; females	0.203 ± 0.002 (42)	-
Ventrals; males	118.7 ± 0.3 (26)	126.2 ± 0.2 (169)
Ventrals; females	125.2 ± 0.3 (46)	133.2 ± 0.2 (155)
Subcaudals; males	42.4 ± 0.6 (26)	46.6 ± 0.2 (133)
Subcaudals; females	36.2 ± 0.2 (42)	39.3 ± 0.2 (125)

[a] Litter size in Clark and Fleet (1976) is 5.3 ± 0.5 (12)
[b] SVL in Clark and Fleet (1976) is 218.0 (12)

Table 2. Morphometric data for *Virginia valeriae* in central Virginia. Values are means ± one standard error. See text for sample sizes.

Measurement	Males	Females
Snout-vent length (mm)	135.1 ± 8.5	145.4 ± 12.5
Tail length (mm)	30.6 ± 2.2	22.5 ± 1.6
Tail length/snout-vent length	0.225 ± 0.004	0.160 ± 0.005
Ventrals	114.6 ± 0.5	119.5 ± 0.7
Subcaudals	35.4 ± 0.5	26.0 ± 0.5

Sex Ratios and Reproduction

Significantly more female *V. striatula* were collected than males ($\chi^2 = 5.0$, Yates continuity correction performed). We found no significant difference in sex ratios of *V. valeriae*.

The smallest gravid *V. striatula* was 175 mm snout-vent length. Thirty-one of the forty-six females (67%) in this study reached or exceeded this size, and mean size of mature females was 210.0 mm (SE = 3.9). Excluding those females below 175 mm and those mature females captured outside the reproductive period (see below), 100% (24/24) possessed yolked eggs and/or embryos or gave birth to young in the laboratory. Size of ovarian eggs apparently begins to increase in late

March or early April, and ovulation occurs by mid to late May (Fig. 1, Table 3). Birth probably occurs in late July or early August. One female bore young in the lab on 10 August. Mean litter size, as based on the number of fertilized or yolked eggs or young, was 6.0 (range 4-10, N = 24).

The smallest gravid *V. valeriae* was 185 mm snout-vent length. Only 6 of the 17 females in this study reached or exceeded this size. Of these, 83% (5/6) possessed enlarged ova or embryos. Mean litter size is 6.6 ± 0.8 (N = 5). Ovarian eggs appear to increase in size at about the same time as those of *V. striatula*, and one female bore four young in the laboratory on 3 August.

Developmental stages (Table 3) of gravid female *V. striatula* seemed to conform closely to Zehr's (1962) scheme. In some females there was a small amount of variation in degree of development of embryos, but never more than three stages were present. Although Zehr recognized 37 stages, in practice the first 5 stages (pre-blastodisc) are difficult to recognize. Later stages can be recognized with some precision, and in our material, development of embryos confirms the timing of reproduction described above.

Most of the male *V. striatula* collected in our study were sexually mature as concluded from convolution of the vasa deferentia and enlargement of the testes. Clark (1964) found that minimum body length of mature males was 142 mm; 69.2% (18/26) of our sample exceeded 164 mm (none in the size interval 138-163 mm were collected), and all had convoluted vasa deferentia. Right testes length in mature *V. striatula* ranged from 5 to 12 mm. No seasonal cycle in testes size could be demonstrated as the length of testes varies with snout-vent length, obscuring temporal variations. At least 53.8% (7/13) of the male *V. valeriae* were over 125 mm and appeared to be sexually mature. These had enlarged testes (6-12 mm) and also had convoluted vasa deferentia.

Food

Only 19.6% (20/102; 12 *V. striatula*, 8 *V. valeriae*) of the *Virginia* collected in this study contained food. All recognizable items consisted of small pieces of red annelids that we were not able to identify further.

DISCUSSION

Clark (1964) published an analysis of an extensive series (324 specimens) of *V. striatula* collected in Brazos County, Texas, and Clark and Fleet (1976) provided ecological data for a population in the same area. Both sites are near the southwestern edge of the species' range (see Conant 1975). Snout-vent lengths and tail lengths of the males in Clark's study differed significantly from those in our study (t = 2.3 and

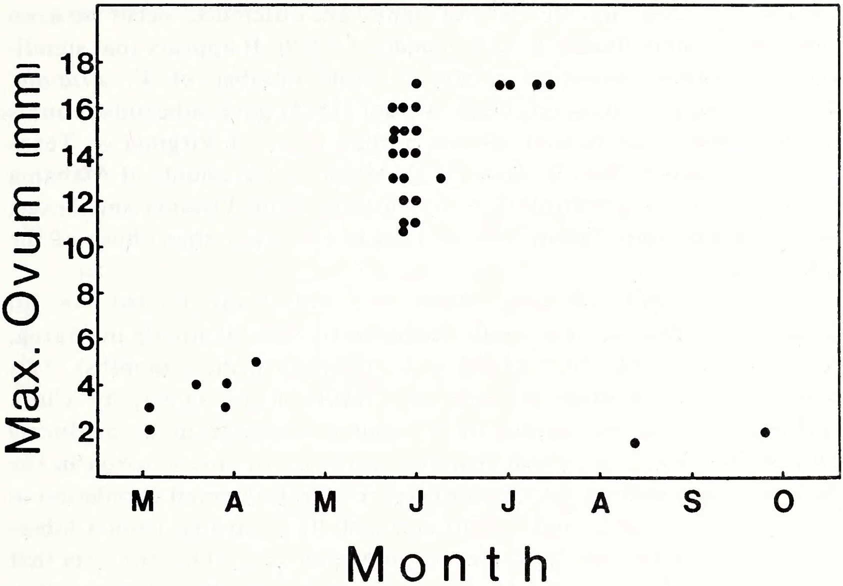

Fig. 1. Seasonal variation in maximum size of ova or ovarian follicles of mature female *Virginia striatula* from Virginia.

Table 3. Stage of development of eggs of the rough earth snake, *Virginia striatula*.

Date	Number of broods	Number of eggs/young	Stage
24 May 1980	5	5,5,6,6,8	<6 to 7
27 May 1980	7	4,5,5,6,6,7,7	yolked ova to 14
31 May 1980	6	4,5,6,7,7,10	<6 to 20
7 June 1976	1	8	26
25 June 1980	1	4	27-28
29 June 1980	1	5	29
7 July 1980	1	9	31-32
9 July 1980	1	4	28-29
10 August 1980	1	7	birth

2.4; df = 193, 157), while those of females did not (t = 1.3 and 1.3; df = 199, 170). There was no significant difference in tail length/snout-vent length ratios (males: t = 1.3; females: t = 0.4). In both our data and those of Clark and of Clark and Fleet, shrinkage corrections were made after the specimens were preserved. Scale counts of Virginia specimens are lower than those of Texas material. Ventral counts differ greatly (males: t = 20.8;

females: t = 22.4). and smaller but significant differences occur between subcaudal counts (males: t = 2.3; females: t = 8.9). It appears that significant geographic variation occurs in scale number of *V. striatula*, although the pattern is not clear. Mount (1975) gave subcaudal counts for Alabama *striatula* that are lower than those of Virginia or Texas specimens (males: 38.5; females: 34.2). Mean ventral counts of Alabama males (121.2) are intermediate between those from Virginia and Texas, while ventral counts from females (124.8) are lower than those of the other states.

Although our collecting efforts were not evenly divided over all months, it is obvious that earth snakes were more available in March, April and May (63/102 = 61.8% were collected in these months). This may be due to increased exposure as a result of mating activity. Clark (1964) concluded that mating of *V. striatula* occurred in Texas during March and April, as judged from the presence of spermatozoa in the lumina of the oviducts. D. Greene (pers. comm.) observed copulation in a group of 30 or more individuals accidentally excavated from a hibernaculum at Richmond, Virginia, on 30 March 1982. This suggests that first mating may occur shortly after emergence from the hibernaculae in early spring.

Size distribution of *V. striatula* in central Virginia seems skewed toward larger snakes. For example, males of *striatula* as small as 123 mm snout-vent length were collected in May, yet only 28.0% (7.25; newborn young excluded) of the entire sample was less than 164 mm (minimum size at maturity). For females, 123 mm also was a minimum size of May specimens, yet only 33.0% did not exceed 175 mm. This bias toward large size indicates either that subadult earth snakes are difficult to find, or that mortality rates of young are relatively great. We believe that the latter hypothesis is correct. Subadult snakes do not seem to behave differently from older snakes, as they often were found with adults or in similar sites. Also, the abundance of small *V. valeriae* supports this contention. About 41.7% (5/12; newborns excluded) of male *V. valeriae* and 57.1% (8/14) of female *valeriae* were shorter than mature individuals. *Virginia valeriae* is not at the northern edge of its range as is *V. striatula* at this collection site. We hypothesize that midwinter mortality of young snakes may be important, as it is in the eastern cottonmouths, *Agkistrodon p. piscivorus* that also reach the northern edge of their range in this area (Blem 1981).

Gravid female *V. striatula* near the northern edge of the range are smaller than those reported by Clark (1964) and by Clark and Fleet (1976) in Texas (Table 1). Since error terms are not available for the Texas sample, statistical comparison is not possible. Clark and Fleet demonstrated a significant regression of litter size on snout-vent length

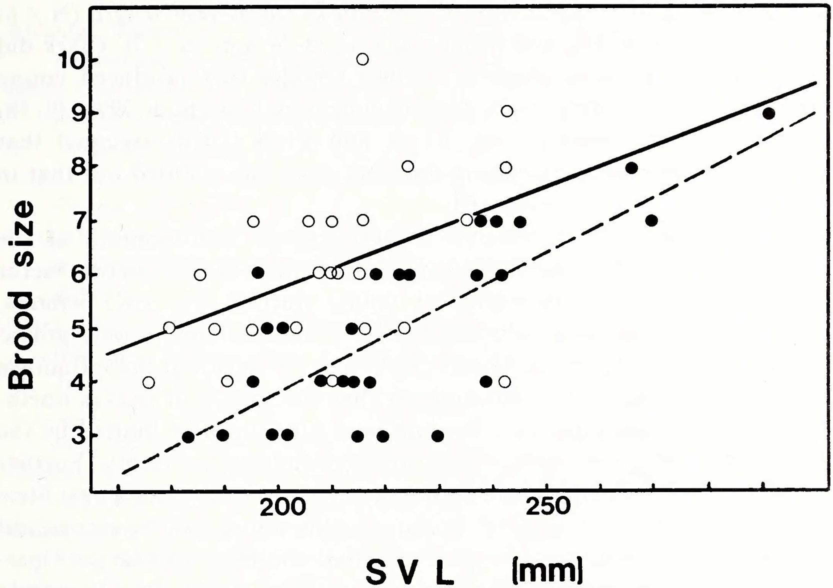

Fig. 2. Brood size as a function of snout-vent length (SVL, mm) in female *Virginia striatula*. Solid circles represent Texas specimens (Clark and Fleet 1976); hollow circles represent Virginia specimens. The dash line is the least-squares best-fit line for Texas snakes (brood size = 0.052 SVL - 6.647, r = 0.77); the solid line is the best-fit line for Virginia snakes (brood size = 0.038 SVL - 1.993, r = 0.46).

in which larger females produce larger numbers of ova or young. Statistical comparison of their data with ours demonstrates a significant inter-locality difference (F = 20.4); slopes and intercepts of equations predicting brood size from female snout-vent lengths are significantly different (see Fig. 2). This means that female *V. striatula* in Virginia produce more eggs per reproductive attempt than do Texas females of similar size. Absolute brood size, as judged from numbers of fertilized ova or young per female, is significantly higher in Virginia females (t = 2.1; df = 38) than the values given by both Clark and Clark and Fleet, but the difference is not statistically significant in the latter comparison.

Further reproductive adjustment may occur through increased ova size. Clark (1964) found that the largest right ovarian follicle was larger than 5 mm only twice in a sample that included over 100 females (many of them over 180 mm snout-vent length), and concluded that one of these was abnormal. In our study, largest right ovarian follicles reached 12 mm and oviductal eggs were 12-17 mm long. Also, while 100% (24/24) of our females were gravid during the reproductive period, not all mature Texas females were. It may be significant that newborn

Texas *V. striatula* ranged from 61-69 mm in snout-vent length (N = 8) while the range of Virginia specimens was 73-79 mm (N = 7). Clark did not calculate the percentage of mature females that produced young each year, but we interpret his data as indicating that about 79% (30/38) should have produced young. Clark and Fleet (1976) assumed that mature females produced young once per year, but pointed out that in some years this was not achieved.

Blem (1981), in an analysis of the eastern cottonmouth at the northern edge of its range in Virginia, found that a major limiting factor was high overwinter mortality of young during very cold winters. Reproductive rates were very high; 83% of mature females were gravid during the breeding season (Blem 1982). The similarity of these findings to those of the present study suggests that the spread of snakes northward on the coastal plain of Virginia may sometimes be limited by the balance between reproductive rate and cold-induced mortality. Further comparison of our studies of *Virginia* and *Agkistrodon*, and a vast literature (e.g. Fitch 1970), suggest that some generalities may be recognized regarding reproductive "strategies" of small colubrids and larger viperids. In general, it appears that less than 100% of mature female viperid snakes reproduce each year and the proportion is often nearer 50% (Aldridge 1979; but see Kofron 1979 and Blem 1982 for exceptions). Conversely, 90-100% of the females of many colubrid species, particularly small snakes such as *Carphophis amoenus*, *Diadophis punctatus* and *Thamnophis sirtalis*, reproduce annually (Aldridge 1979). It therefore appears that one might expect a large proportion of the females of a population of *V. striatula* to be involved in the production of young each year. In many studies addressing reproductive output of snakes, a relationship has been noted between litter size, or some other measure of reproductive output, and female size (see Blem 1981, 1982). Both small colubrids (e.g. Clark 1964) and viperids show this phenomenon. However, frequency of reproduction appears to be a size-related phenomenon in some viperids (Burkett 1966; Blem 1982), while that relationship has not been demonstrated for small colubrids.

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